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AN INTEGRATING DEVICE FOR USE WITH
PRESSURIZED IONIZATION CHAMBERS

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Eastern Environmental Radiation Facility

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16. ABSTRACT A low-cost, commercially available electronic integrator has been adapted for use with the Reuter-Stokes Model RSS-111 pressurized ionization chamber. The integrator provides a readout of the total exposure accumulated during the integration period. This precludes the necessity of manually integrating the area under a lengthy strip chart curve. Use of the integrator with the RSS-111 is quite simple and requires no major modification of the ionization chamber. Field and laboratory tests of the integrator have shown it to produce consistent results over both short and long integration times, and at both high and low exposure rates.		
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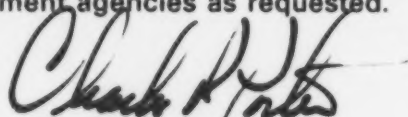
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PREFACE

The Eastern Environmental Radiation Facility participates in the identification of solutions to problem areas as defined by the Office of Radiation Programs. The Facility provides laboratory capability for evaluation and assessment of radiation sources through environmental studies and surveillance and analysis. The EERF provides technical assistance to the State and local health departments in their radiological health programs and provides special laboratory support for EPA Regional Offices and other federal government agencies as requested.



Charles R. Porter
Acting Director

Eastern Environmental Radiation Facility

An Integrating Device for Use with Pressurized Ionization Chambers

Introduction

The proposed AEC Regulation 10CFR50 Appendix I limits radiation dose equivalent at the site boundary of light water power reactors to a maximum of 5 millirem per year (mrem/yr) above natural background. A dose equivalent of 5 mrem/yr added to a natural background dose equivalent of 100–120 mrem/yr is virtually impossible to measure using monitoring devices such as film badges or thermoluminescent dosimeters. The Health and Safety Laboratory (HASL) of the U. S. Atomic Energy Commission describes in HASL-260 a high pressure ionization chamber designed to accurately measure ambient environmental radiation exposure rates. A commercial instrument similar to the HASL chamber is now available from Reuter Stokes (Model RSS-111). This instrument has gained rather widespread acceptance in the nuclear power field. Several of the instruments have been used by the EERF for over a year with very satisfactory results.

The basic RSS-111 pressurized ionization chamber (PIC) as marketed by Reuter Stokes is equipped with a panel meter readout and a strip chart recorder. For short-term or real time measurements these forms of data presentation are entirely satisfactory. However, for long-term field monitoring which we routinely perform for periods from 1–3 months duration, visual reduction of the voluminous strip chart data using a planimeter is quite time consuming. An optional magnetic tape recorder is to be offered by Reuter Stokes. After storing data the magnetic tape is read into a computer for data processing. This system of data handling, however, is rather expensive (~\$4,000) and it requires the user to have a computer available for data retrieval.

As an option to the readout methods described above, the EERF has adapted a low cost, commercially available integrator module to work in conjunction with the recorder and panel meter which are standard on the RSS-111, making a very versatile arrangement. The integrator may be disengaged when real-time or short-term measurements only are necessary. When using the integrator in conjunction with the strip chart recorder for long-term measurements, the readouts provide total exposure, and the time and exposure rates of intermittent exposures. This report describes the integrator and provides details for its use in conjunction with RSS-111.

General Description

The integrator adapted for use with the RSS-111 is manufactured by Curtis Instruments, Inc. Integration of current is performed with a mercury microcoulometer.

The microcoulometer consists of a glass capillary tube containing two columns of mercury separated by an electrolyte. Wire electrodes are inserted into the mercury columns through the ends of the capillary for electrical connection (Figure 1). When a direct current is passed through the coulometer, mercury is deposited across the electrolyte gap which causes the gap to move toward the anode. The movement of the electrolyte is directly proportional to the current/time integral.*

A metal sheath is positioned around the exterior of the capillary such that the length of either mercury columns can be determined electronically by measuring the capacitance between the sheath and the column of mercury, which varies in length as the gap moves.

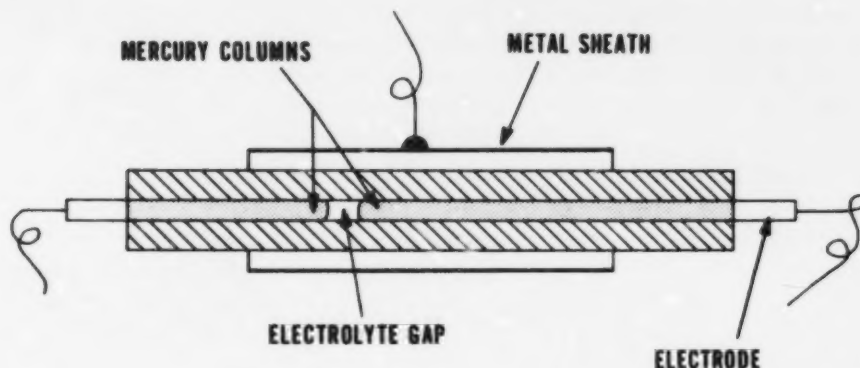
Unlike electronic integration which depends upon the state-of-charge of a capacitor, the mercury microcoulometer does not undergo leakage and loss of data over a long storage period. This characteristic is very important since long-term integration with maximum stability is essential in this application.

It was desired to obtain an integrator which would require no electronic modifications to the RSS-111. After learning of our specific requirements, Curtis Instruments was able to produce a unit which was compatible with the RSS-111. Ranges of current to be integrated, type of data readout, and characteristics of the RSS-111 were taken into account when adapting the integrator for our application.

Data from the integrator are presented on two devices, a panel meter and a mechanical register. As current flows and the electrolyte gap moves in the capillary, its position is indicated on the panel meter. Total range movement of the gap corresponds to full scale deflection of the meter and to an integrated exposure of 50 microroentgens, depending on the calibration. When the electrolyte gap reaches the end of its travel the polarity of the electrodes is automatically reversed, the panel meter is reset to zero, and one count is registered on the mechanical register. For each 50 microroentgens exposure integrated, one count will be recorded. Thus, with a mechanical register having five decades, it is possible to integrate large exposures over a long period of time with no data overflow and at the same time very small exposures are easily and accurately recorded.

* C.C. Beusman, "Electrochemical Devices for Timing and Switching Applications," IEEE International Convention Record, March 1964.

Figure 1. Mercury Microcoulometer



Installation

In keeping with our desire to perform no electronic modifications to the RSS-111, the integrator derives its input signal from the output jacks which are present on the front panel of the RSS-111. Power to operate the integrator ± 12 volts DC, is obtained from the RSS-111, however, to obtain $(+)$ 12 volts with respect to ground it is necessary to ground the negative side of the recorder motor supply. This is the only modification necessary to the RSS-111, and it does not detract from the instrument's independent performance in any way.

The RSS-111 is designed to operate from 110 volts AC or from an internal, rechargeable battery pack for up to 200 hours. The integrator, however, requires too much current to operate from this battery pack for extended periods, and for this reason the integrator is designed to operate from 110 volts AC only. The RSS-111, when operating from 110 volts AC, will automatically switch to the battery pack power supply should the AC source be interrupted. During field testing of the integrator it was found that when this automatic changeover occurs and the integrator is no longer receiving its ± 12 volt DC supply voltage (due to excess battery drain) damage will occur to the integrator. This damage occurs since the signal from the RSS-111 is still present and driving the coulometer, however the polarity reversing circuitry is inoperative thus driving the coulometer beyond its capacity. This may be prevented by using a three pole relay as shown in (Figure 2). When 110 volts AC is not present, the supply voltages and signal are disconnected from the integrator.

Two versions of the integrator have been obtained from Curtis Instruments. In the first version which cost \$425, the integrator circuitry and readout units are all

mounted within a metal case (Figure 3). Signal and power connections to the RSS-111 are made using appropriate cables from a terminal strip on the back of the integrator case. This version is quite easy to put into operation and requires no major modifications to the RSS-111. Also, this arrangement allows the integrator to be used alternately with several PIC's since it is easily connected and disconnected through the use of jacks on the front panel of the PIC.

In the second version of the integrator, which cost \$380, the components are supplied without a case. These components include a printed circuit board, a panel meter, and a mechanical register (Figure 4). These components can be installed directly in the case of the PIC, (Figure 5). This arrangement produces a very compact and rugged arrangement. Both versions work equally well.

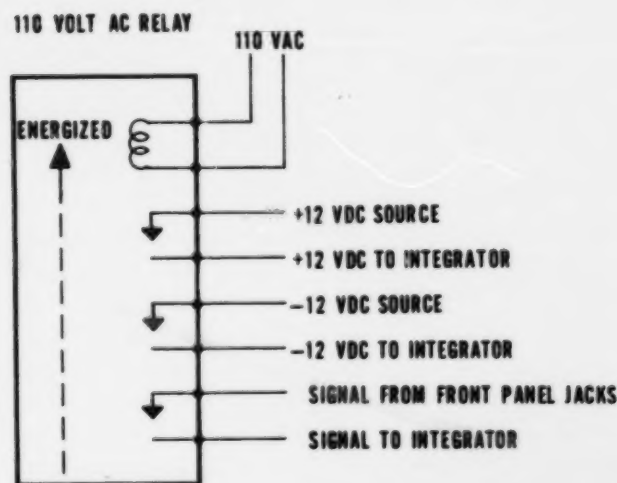


Figure 2.
Protective
Circuit for
Integrator

Figure 3.
Integrator Mounted
in External Case

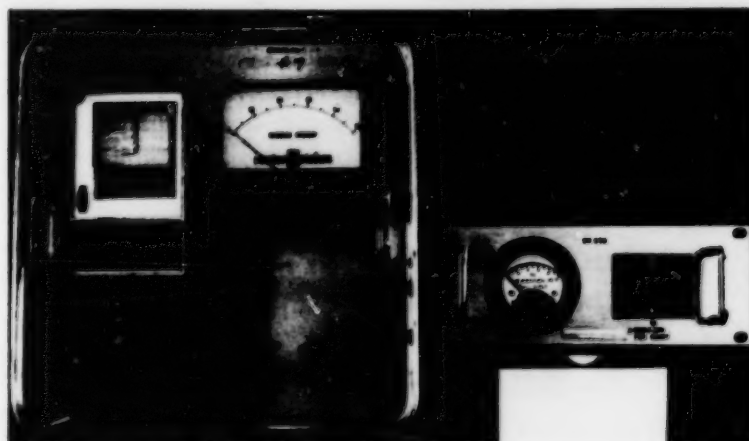
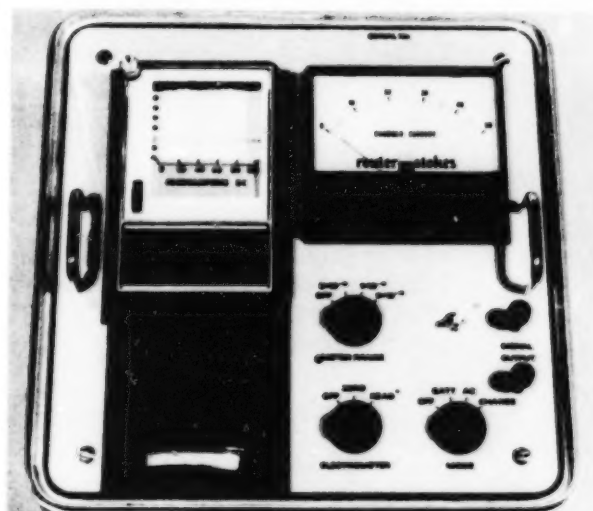




Figure 4.
Components
of Integrator

Figure 5. Components
Installed in PIC Case



Laboratory Calibration

Prior to use of the integrator it is necessary to establish the exposure relationship between the recorder and the integrator. It is assumed that the recorder has been previously calibrated either by Reuter Stokes or by the user. A high resolution potentiometer is provided on the integrator so that it can be adjusted to minimize the scaling error between the recorder and the integrator. Proper adjustment of the potentiometer, following the instructions provided by Curtis Instruments, should result in errors less than $\pm 3\%$.

Having made this adjustment the error may be determined in the laboratory by using a small radioactive source to expose the ionization chamber at a constant rate with both the recorder and the integrator operating. The total exposure should be at least several hundred microroentgens. At the end of the exposure period the

"true" exposure is determined by integrating the area under the curve produced by the recorder. This may then be compared to the integrator readout which should be the same if the scaling adjustment is correctly set.

Field Testing

Testing in the field has provided comparative results between the recorder and the integrator. Tests were run at exposure rates ranging from 6 microroentgens/hour up to 165 microroentgens/hour and for both short and long integration periods. Results of these tests are presented in Table 1.

Table 1. Comparison of Total Exposures as Determined by the Recorder and by the Integrator in Field Tests

Test	Integration of Recorder Tape (microroentgens)	Integrator Reading (microroentgens)	Percent Difference
1	1271	1295	1.9%
2	1465	1411	2.7%
3	3048	3035	0.4%
4	1645	1655	0.6%
5	1236	1250	1.1%
6	1226	1237	0.9%

Differences between the recorder and the integrator are seen to be quite small. A likely source of these differences arises from the inaccuracy of using a planimeter on a long recorder tape.

Summary

The integrator described has been used with good results and no malfunctions. The low cost makes the integrator particularly appealing compared to other methods of data integration which are available. No major modifications to the RSS-111 ionization chamber are required for use of the integrator.

Field and laboratory testing of the integrator have shown the unit to produce good results at both high and low exposure rates for extended periods of time.